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GEOGRAPHIC AND MONTHLY VARIATION OF RAPID INTENSIFICATION AND LOW-LATITUDE WEAKENING OF TROPICAL CYCLONES OF THE WESTERN NORTH PACIFIC OCEAN

by

SAMSON BRAND

MAY 1972

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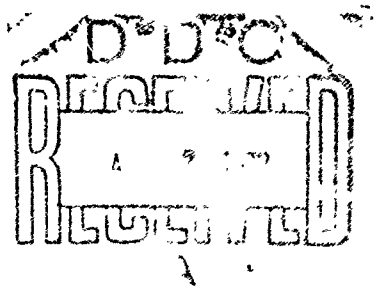

ENVIRONMENTAL PREDICTION RESEARCH FACILITY
NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

Twenty-five years of tropical storm and typhoon data for the western North Pacific (1945-1969) were evaluated to determine the geographic and seasonal variation of those tropical cyclones which rapidly intensified over the open ocean (≥ 50 knots increase in 24 hours) and those tropical cyclones that weakened at low latitudes over the open ocean (≥ 20 knots decrease in 24 hours, south of 25N). The results show distinct geographic and seasonal preferences for both rapid intensification and low-latitude weakening of tropical cyclones.( )

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1. INTRODUCTION

The tropical cyclone forecaster is concerned with two major problems once a tropical cyclone has been detected. The first is the movement of the storm and the second is that of the future intensity of the storm in question. As an important step toward understanding the effect of the ocean-atmosphere system on tropical cyclone intensity, the intensity characteristics of storms have been examined. In a previous publication (Brand and Gaya, 1971) the forecaster was given statistical information on the geographic and seasonal variations of tropical cyclone intensity changes based on 25 years (1945-1969) of tropical storm and typhoon data. Tables were presented for 10° x 10° latitude/longitude areas of the western North Pacific, for each month, and for the 12-, 24-, and 48-hour changes in intensity of tropical cyclonic circulations which, during their life cycle, reached tropical storm or typhoon intensity for the period 1945-1969. Intensity changes were presented in terms of initial intensity as well as a category independent of initial intensity.[1]

Rapid intensification (defined here as an increase in maximum surface wind of 50 knots or more in 24 hours) is unusual.

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[1]Examples of the geographic variations of the intensity changes can be seen in Appendix A.

2. DATA SOURCES

The data used for this study were extracted from a history file of tropical storms[1] and typhoons[2] of the western North Pacific, for the period 1945-1969, compiled by the National Climatic Center (NCC) for and with the Navy Weather Research Facility (Hodge and McKay, 1970). This history file is comprised of data from the following sources:

a. Synoptic Charts

Period	Preparing Agency	Location
1/45 - 12/47	U.S. Air Force Weather Central	Andrews AFB, Md.
1/45 - 4/60	U.S. Air Force Weather Central	Tokyo, Japan
7/45 - 12/45	U.S. Weather Bureau	Washington, D.C.
1/54 - 12/67	U.S. Air Force, Anderson AFB	Guam, M.I.
5/59 - 12/66	U.S. Navy, FLEWEACEN/JTWC	Guam, M.I.
1/67 - 12/69	ESSA, NMC	Washington, D.C.
1/45 - 12/54	U.S. Navy and U.S. Air Force	Various

b. Publications

Annual Typhoon Reports. Fleet Weather Central/Joint Typhoon Warning Center, Guam, 1953-1969.

Memoirs of the Central Meteorological Observatory, Japan.

A Report on the Typhoons and Tropical Depressions (Philippines), 1947-49, 1951-54, and 1956-58.

Meteorological Results of Royal Observatory, Hong Kong, 1947-58.

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[1] Tropical cyclonic circulations which at one time in the life cycle of the storm reached tropical storm intensity.

[2] Tropical cyclonic circulations which at one time in the life cycle of the storm reached typhoon intensity.

3. DISCUSSION OF RESULTS

The monthly frequency distribution of tropical cyclone occurrences (6-hourly), during the period 1945-1969, is presented in Figure 1. These 6-hourly occurrences are based on available data for the period from sources listed in Section 2. The 25 years of data indicates an August-September peak for tropical cyclone occurrences (solid line). When the tropical cyclone occurrences are stratified in terms of tropical cyclone intensity, August shows a peak for occurrences having intensities < 64 knots (less than typhoon intensity). September shows a peak for occurrences having intensities ≥ 64 knots (typhoon intensity). Notice that from January through August the number of typhoon intensity occurrences is less than the number of occurrences of storms having less than typhoon intensity; whereas, from September through December the converse is true. It is also interesting to note for the month of August the relatively large difference between the number of occurrences having intensities < 64 knots and the number of occurrences of typhoon intensity.

August is also the month in which tropical cyclones seem to intensify less rapidly than in the other months of the typhoon season. This can be seen in Figure 2 which presents the monthly distribution of the average maximum

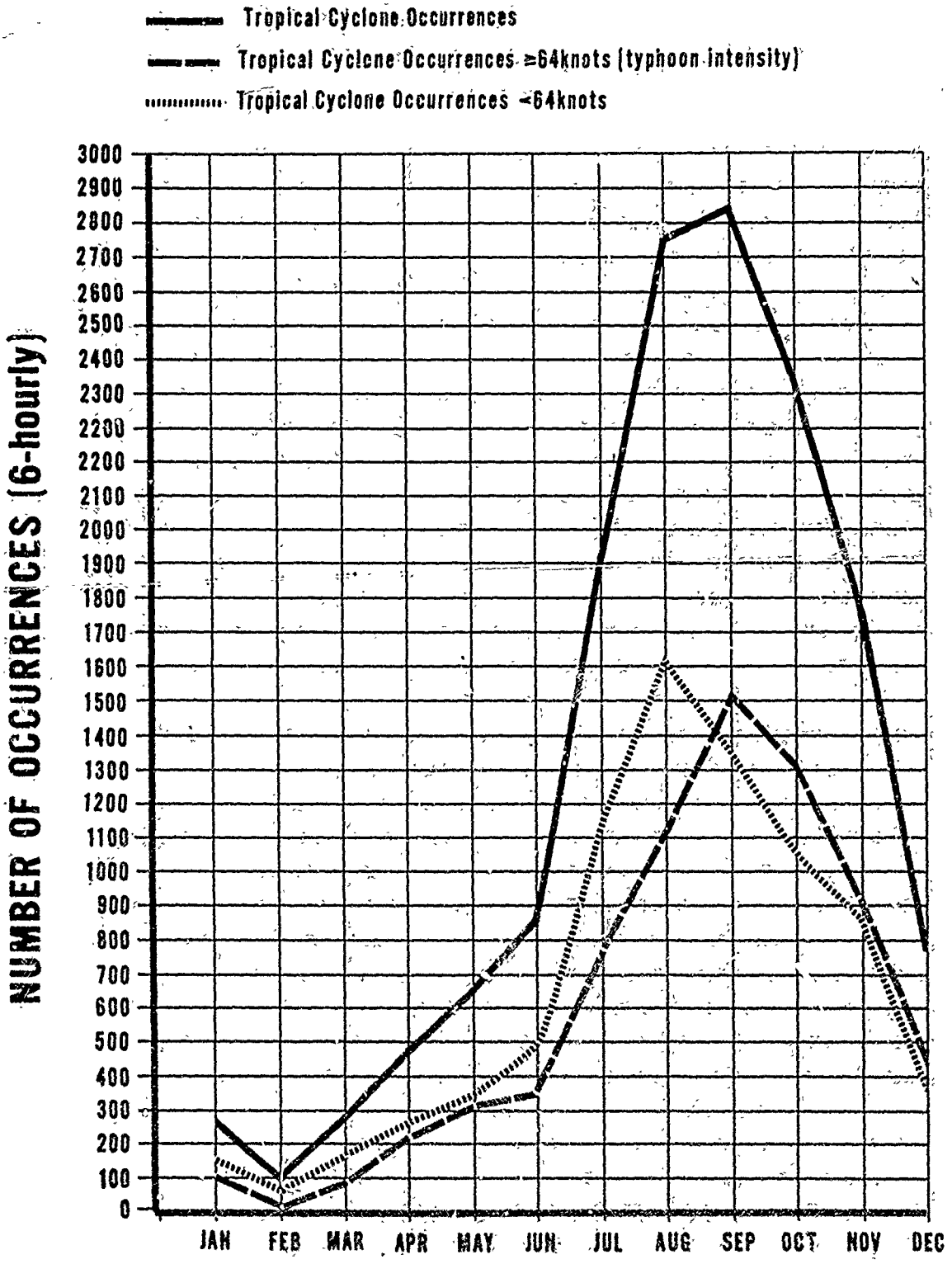


Figure 1. Monthly frequency distribution of tropical cyclone occurrences in the western North Pacific for tropical cyclones which reached tropical storm or typhoon intensity. The occurrences are based on 6-hourly reports during the period 1945-1969.

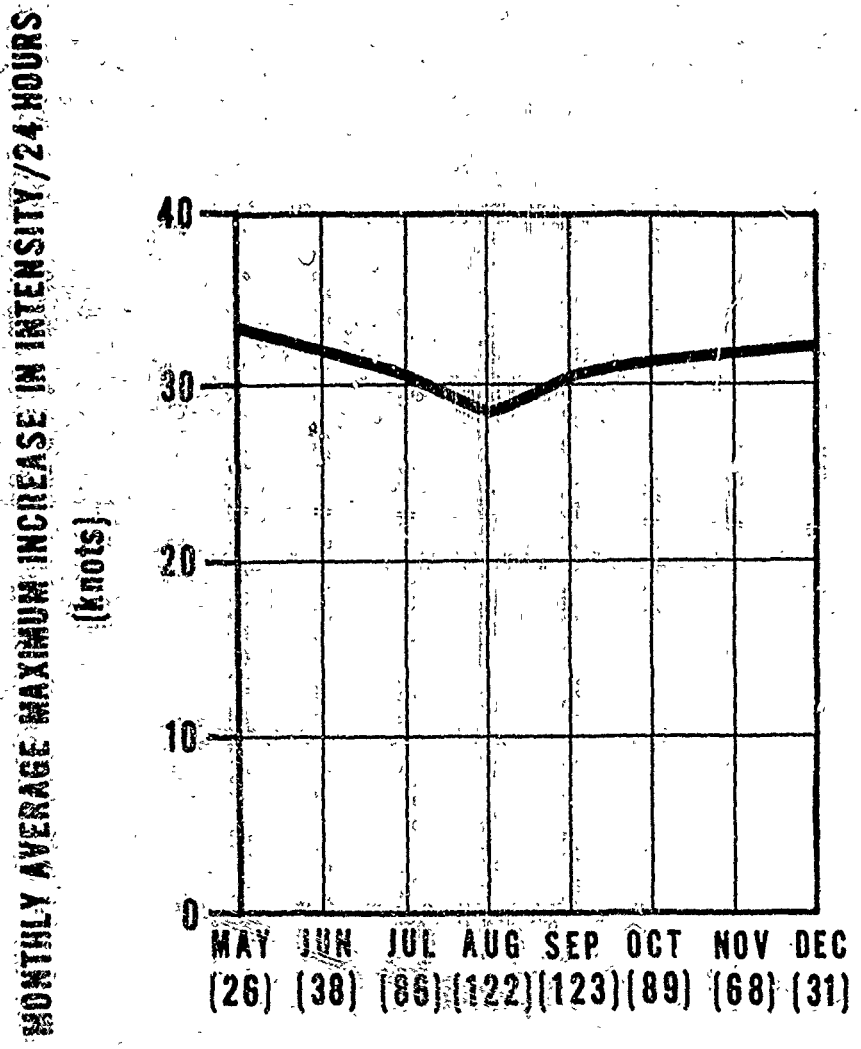


Figure 2. Monthly distribution of the average maximum 24-hour increase in intensity of intensifying tropical cyclones which reached tropical storm or typhoon intensity during their lifetime (May-December). The number of tropical cyclones on which the averages are based are shown in parentheses below each month. Not all tropical storms and typhoons that occurred from 1945 to 1969 are included in these statistics because some tropical cyclones were discovered during maximum intensification or during dissipation.

increase in intensity, occurring over a 24-hour period during intensification. It should also be noted that August is the month that has the greatest number of very small intense typhoon occurrences (Brand, 1970) and the most cold-core origin tropical cyclones.

The annual average 24-hour maximum increase in intensity is 30.7 knots for intensifying tropical cyclones which during their lifetime reached tropical storm or typhoon intensity. Thus, a storm exhibiting an increase in intensity of 50 knots in 24 hours is well above average and should be limited in frequency.

3.1 Rapid Intensification

Figure 3 presents the monthly frequency distribution of occurrences of tropical cyclones which intensified by 50 knots or more in 24 hours. The number of occurrences is based on the number of 6-hourly occurrences during the period for which tropical cyclones intensified by 50 knots or more in 24 hours; the number in parentheses below each month is the number of individual tropical cyclones associated with these 6-hourly occurrences. The number at the top of the

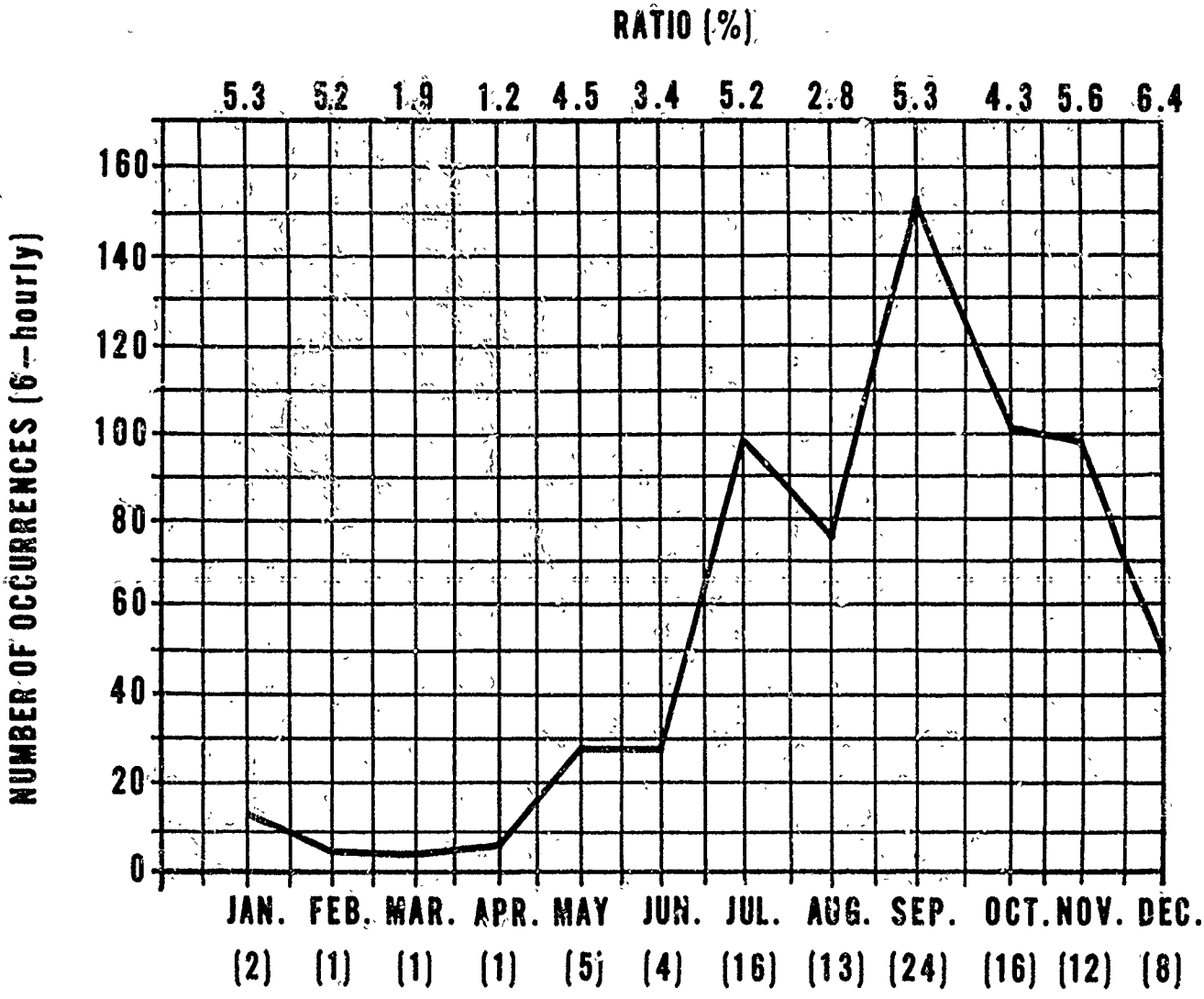


Figure 3. Monthly frequency distribution of occurrences of tropical cyclones which intensified by 50 knots or more in 24 hours. The number of occurrences is based on the number of 6-hourly occurrences during the period in which the tropical cyclones were intensifying by 50 knots or more in 24 hours. The number in parentheses below each month is the number of individual tropical cyclones associated with these 6-hourly occurrences. The number at the top of the graph is the ratio (%) of these occurrences to the total number of tropical cyclone occurrences (see Figure 1).

graph is the ratio (%) of "rapid intensification" occurrences (Figure 3) to the total number of tropical cyclone occurrences (Figure 1). It can be seen that August has a dip in the general trend. This dip is especially evident in the ratio of rapid intensification occurrences to total number of tropical cyclone occurrences.

Only 13 August tropical cyclones out of a possible 122 (see tropical cyclone count given in parentheses below each month of Figure 2) showed an increase of maximum wind by 50 knots or more, while 24 out of 123 did so in September; 16 out of 86 in July; and 16 out of 89 in October.

It is interesting to note that when an intensification criterion of 40 knots in 24 hours is used, the August dip is not present as seen in Figure 4. Figures 3 and 4 are similar in many respects, apart from the large difference in August. Notice that is quite common for August and September tropical cyclones to intensify by 40 knots in 24 hours. In fact, 37% (45 out of 122) of the August and 39% (48 out of 123) of the September tropical cyclones have done so, based on 25 years of history.

If those segments of the tracks of tropical cyclones which intensified by 50 knots or more in 24 hours are plotted for each month, the geographic variations of this rapid

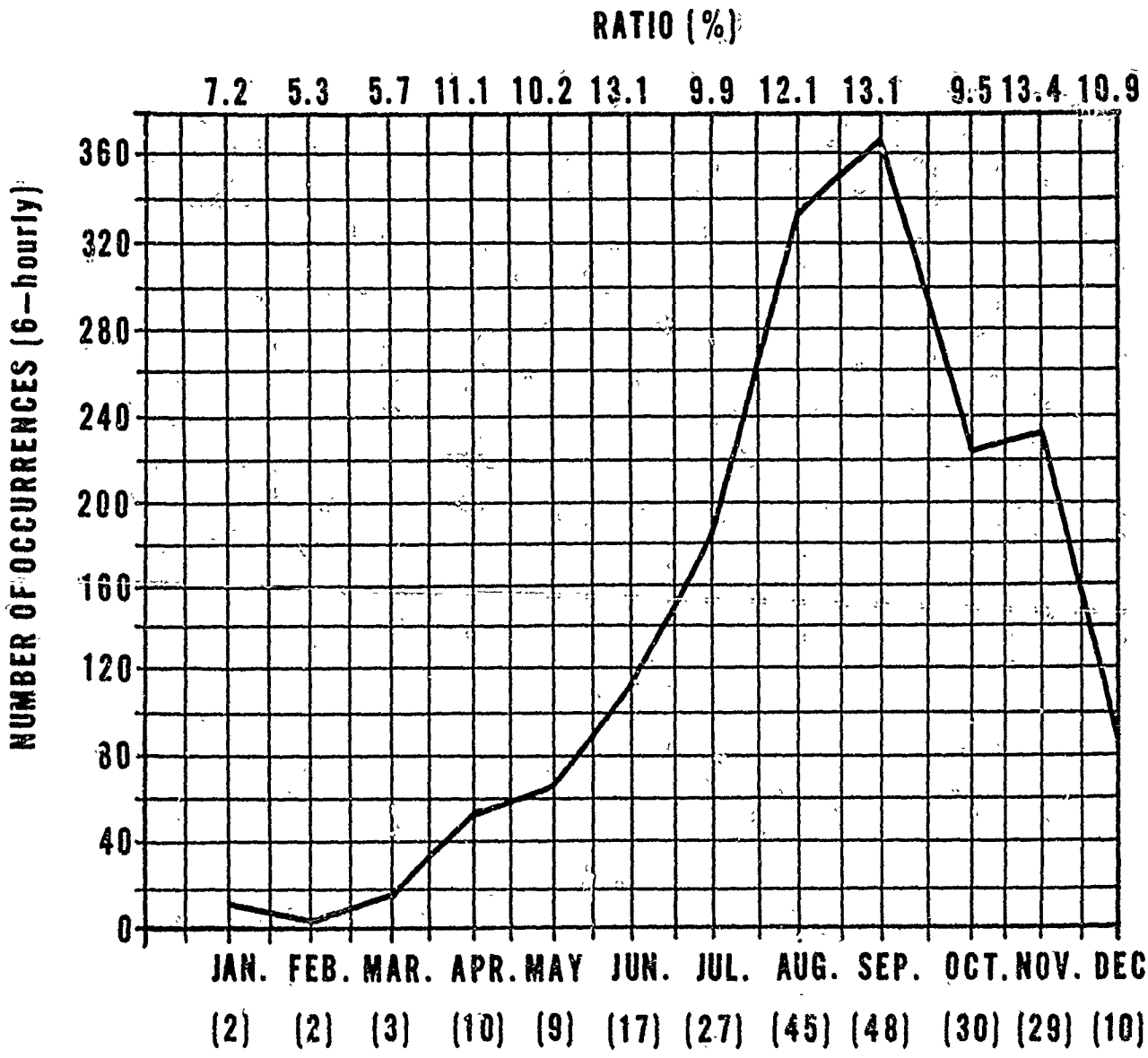


Figure 4. Monthly frequency distribution of occurrences of tropical cyclones which intensified by 40 knots or more in 24 hours. The number of occurrences is based on the number of 6-hourly occurrences during the period in which the tropical cyclones were intensifying by 40 knots or more in 24 hours. The number in parentheses below each month is the number of individual tropical cyclones associated with these 6-hourly occurrences. The number at the top of the graph is the ratio (%) of these occurrences to the total number of tropical cyclone occurrences (see Figure 1).

intensification can be seen. Figures 5 through 9 present these rapid intensification track segments (part (a) of Figures 5-9) for the months of July through November (the peak months of the typhoon season) and these can be compared with the monthly tropical storm and typhoon tracks (parts (b) and (c) of Figures 5-9).

Notice that rapid intensification occurs in preferred areas in each of the months, but 26N seems to be the upper northern limit for these rapid intensification segments. From August to October, the preferred areas for rapid intensification seem to move toward the south and east. November shows a concentrated region approximately between 10-15N to the east of the Philippines.

3.2 Low-Latitude Weakening

In the same manner in which tropical storms and typhoons were examined for rapid intensification, an examination was made of those storms that weaken at low latitudes. Two criteria were used to define weakening: 1) that a decrease in maximum surface wind of at least 20 knots occur within a 24-hour period; and 2) that the decrease occur south of 25N. The segments of the tracks of tropical cyclones fitting these criteria were plotted for the months of July through November and can be seen in Figures 10(a) through 10(e). Again, comparisons should be made with the monthly tropical storm and typhoon tracks (refer to Figures 5 through 9).

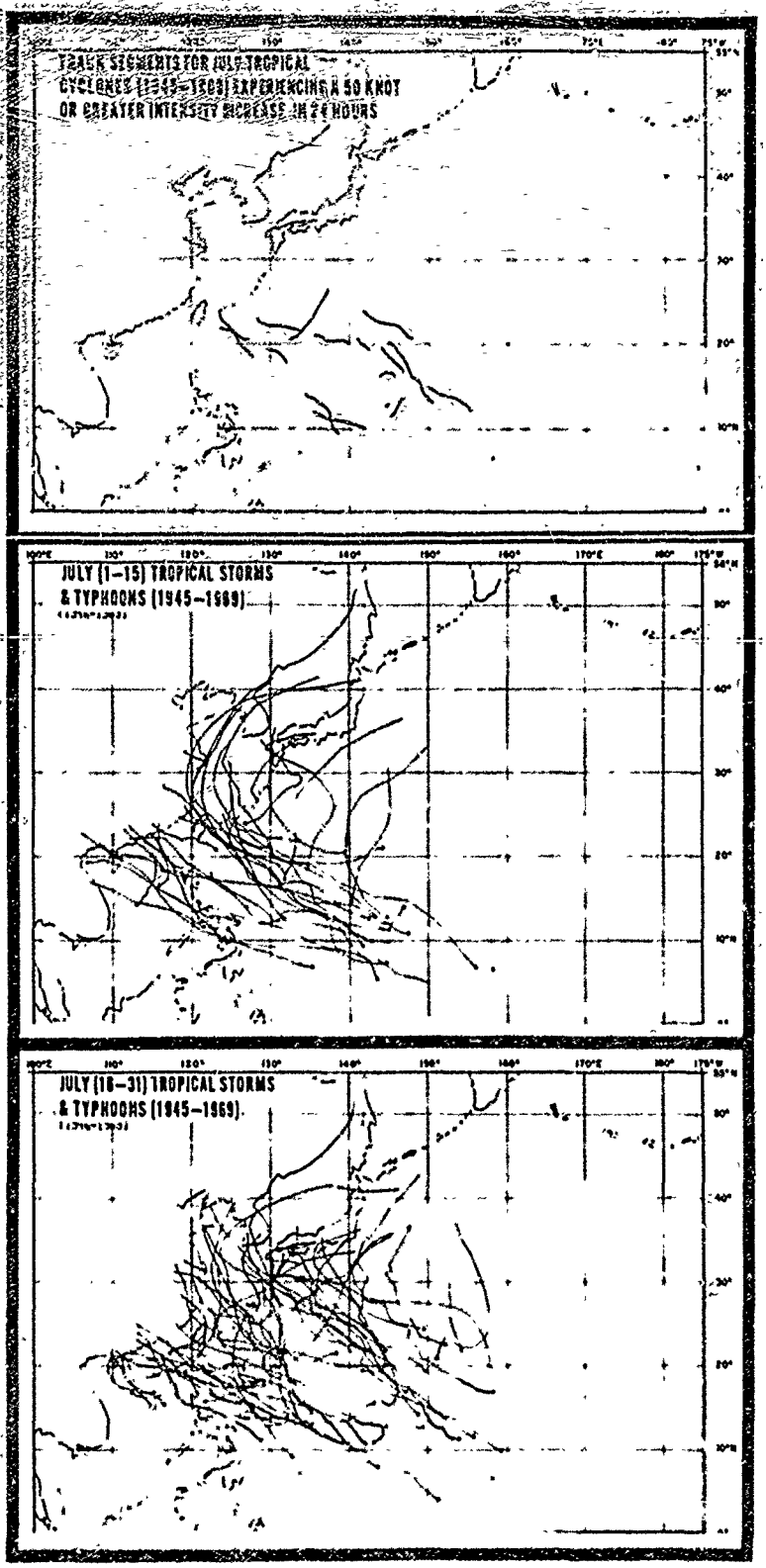


Figure 5. Track segments for July tropical cyclones (1945-1969) experiencing a 50-knot or more intensity increase in 24 hours (a) and the tropical storm and typhoon tracks for the first half (b) and second half (c) of July.

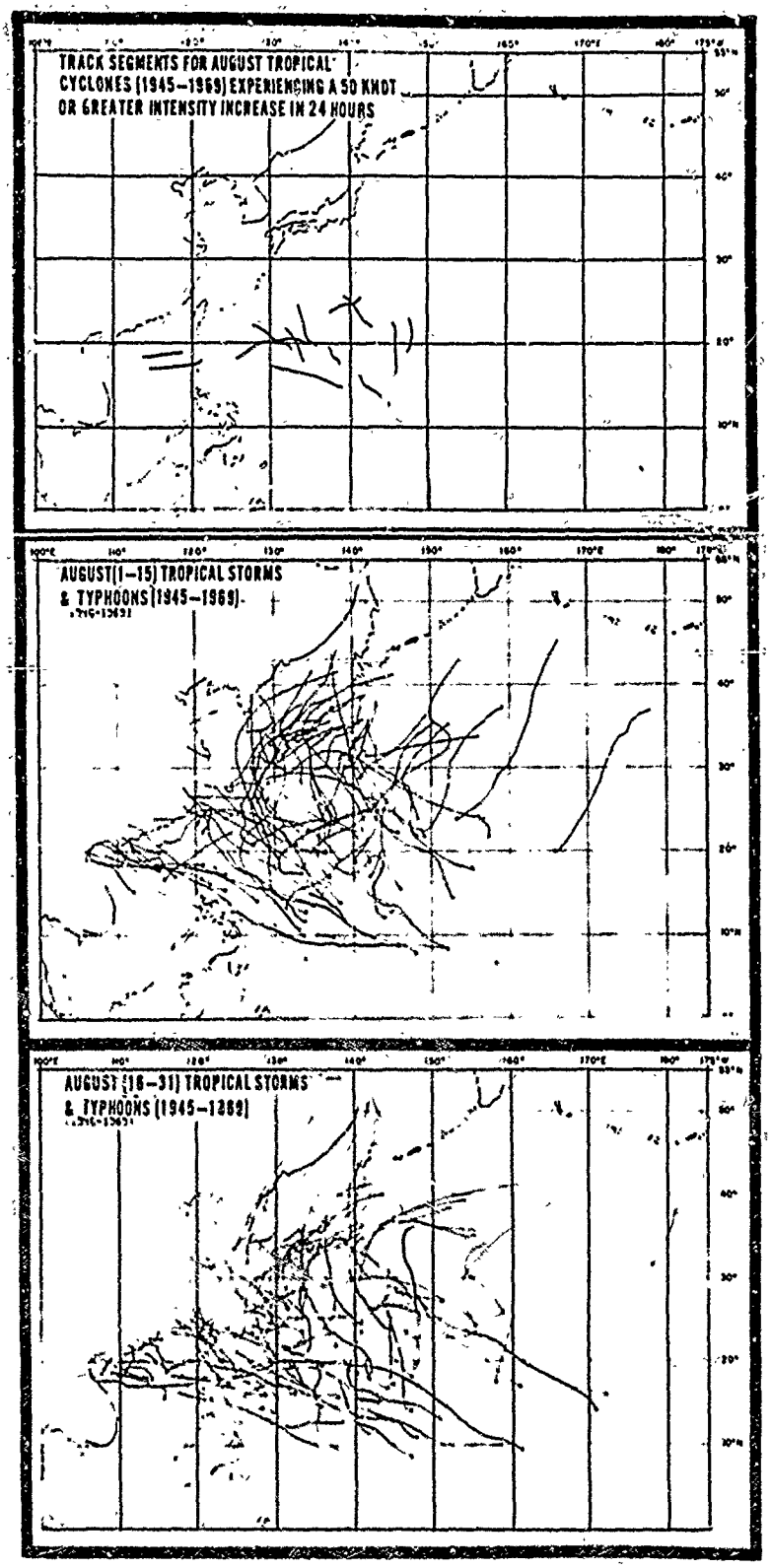


Figure 6. Track segments for August tropical cyclones (1945-1969) experiencing a 50-knot or more intensity increase in 24 hours (a) and the tropical storm and typhoon tracks for the first half (b) and second half (c) of August.

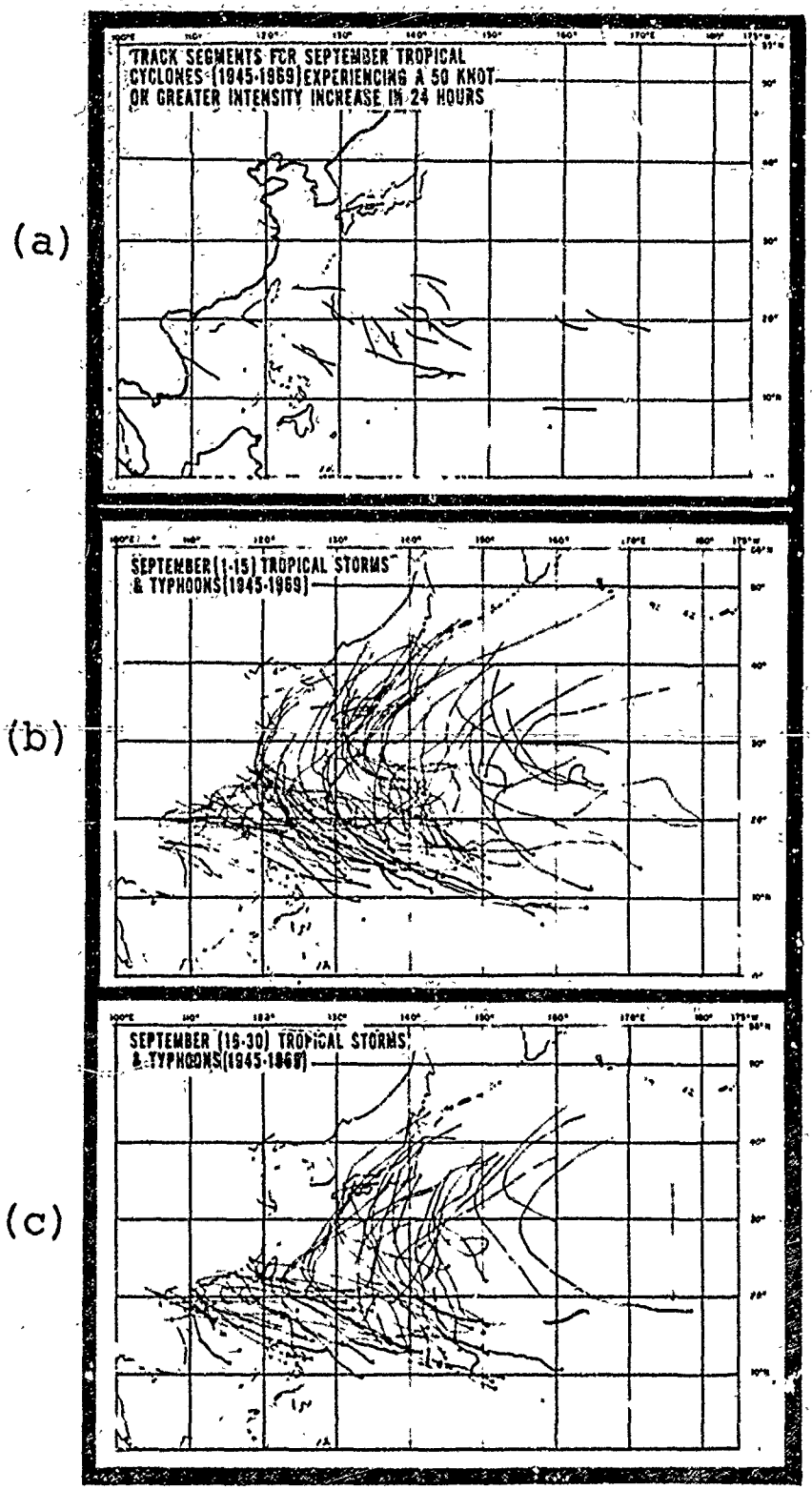


Figure 7. Track segments for September tropical cyclones (1945-1969) experiencing a 50-knot or more intensity increase in 24 hours (a) and the tropical storm and typhoon tracks for the first half (b) and second half (c) of September.

(a)

(b)

(c)

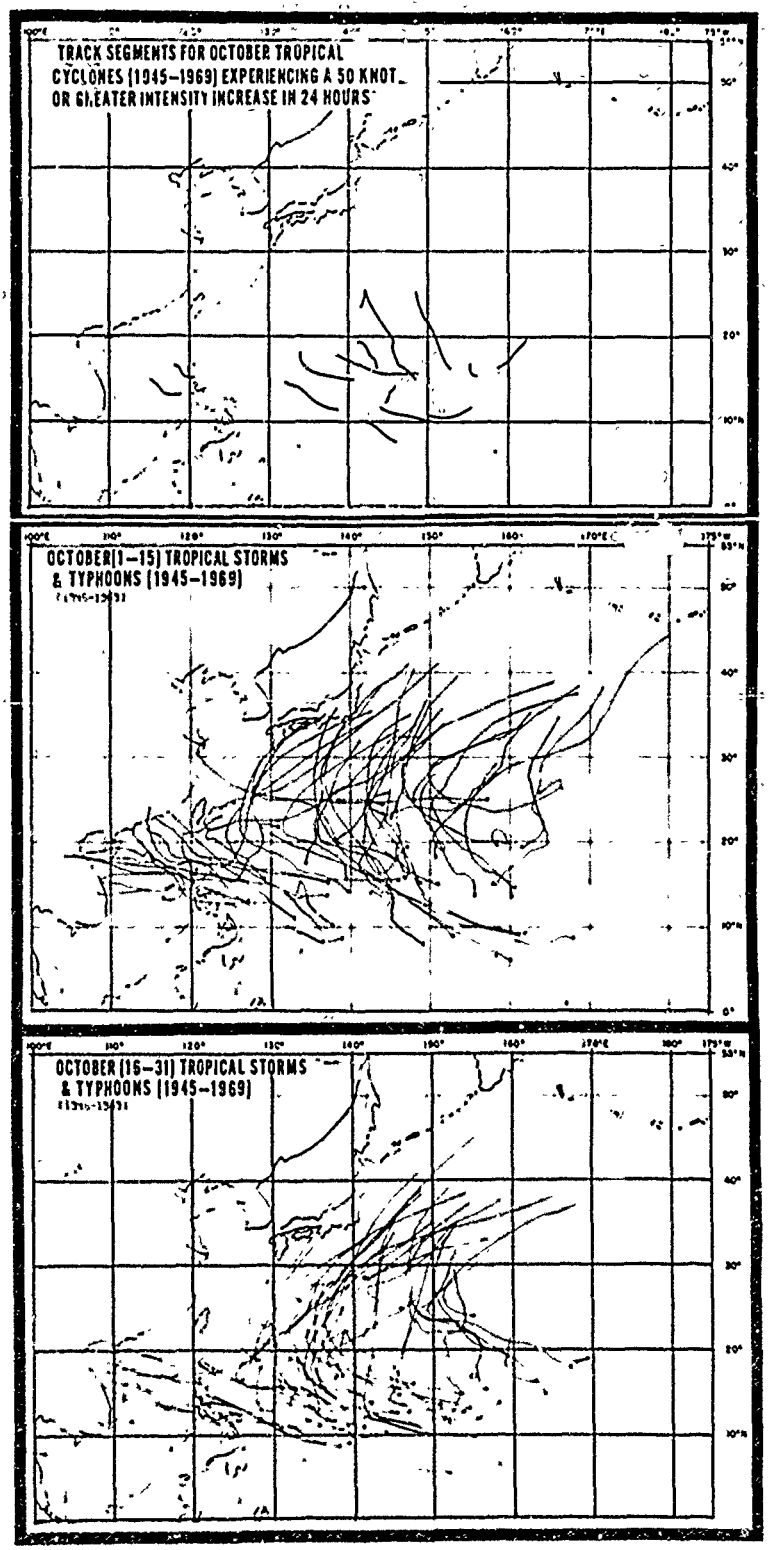
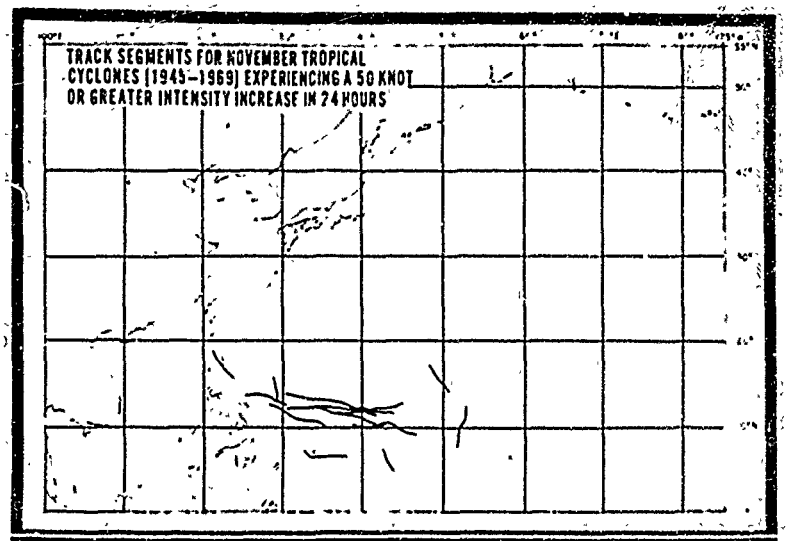
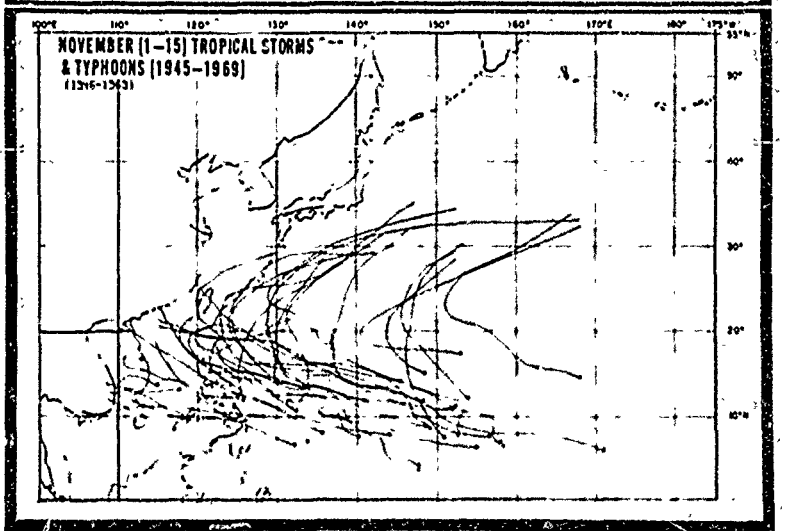


Figure 8. Track segments for October tropical cyclones (1945-1969) experiencing a 50-knot or more intensity increase in 24 hours (a) and the tropical storm and typhoon tracks for the first half (b) and second half (c) of October.

(a)



(b)



(c)

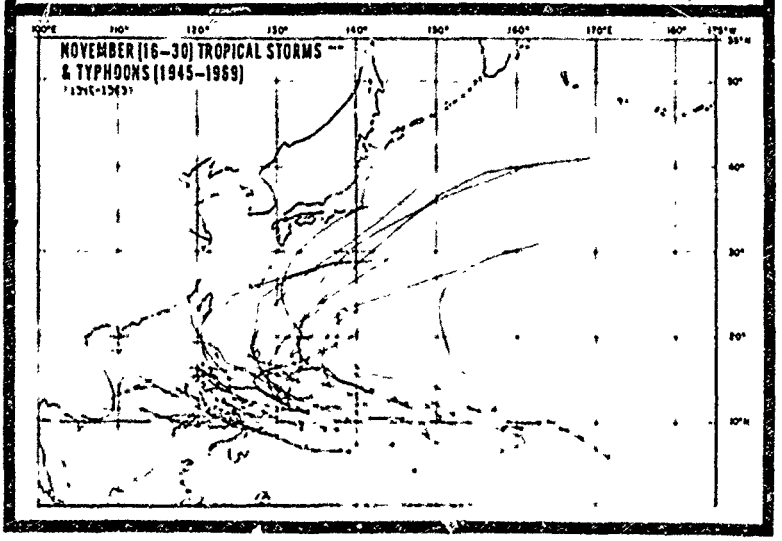
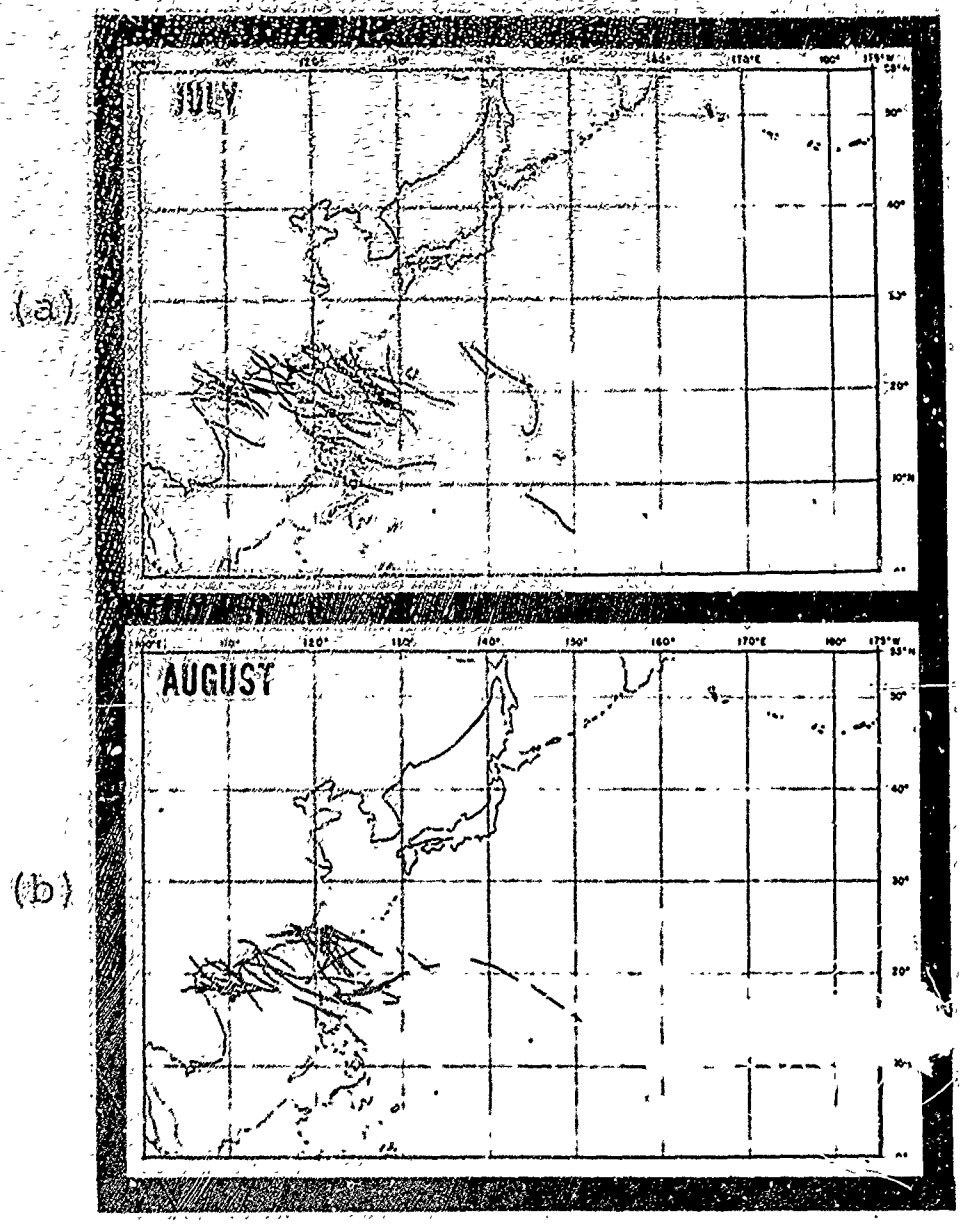


Figure 9. Track segments for November tropical cyclones (1945-1969) experiencing a 50-knot or more intensity increase in 24 hours (a) and the tropical storm and typhoon tracks for the first half (b) and second half (c) of November.

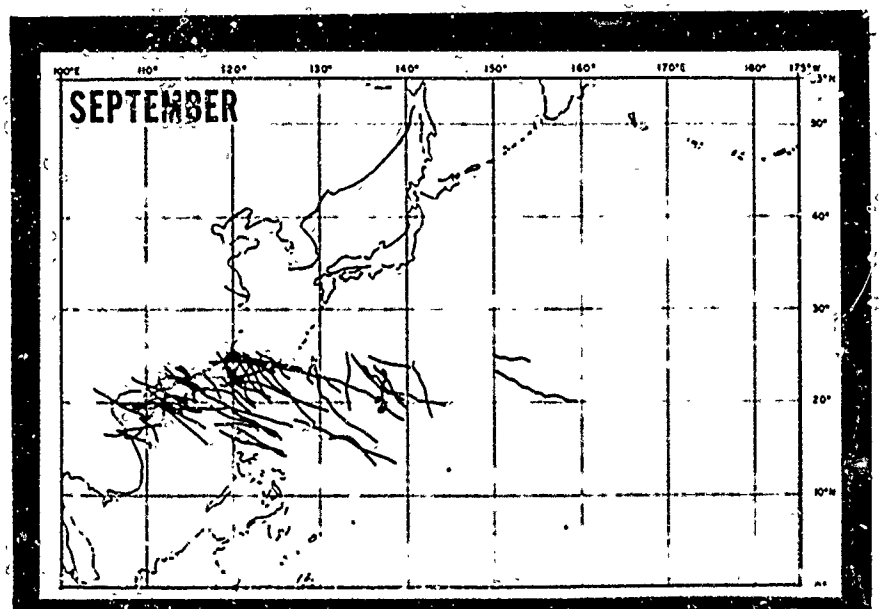


(a)

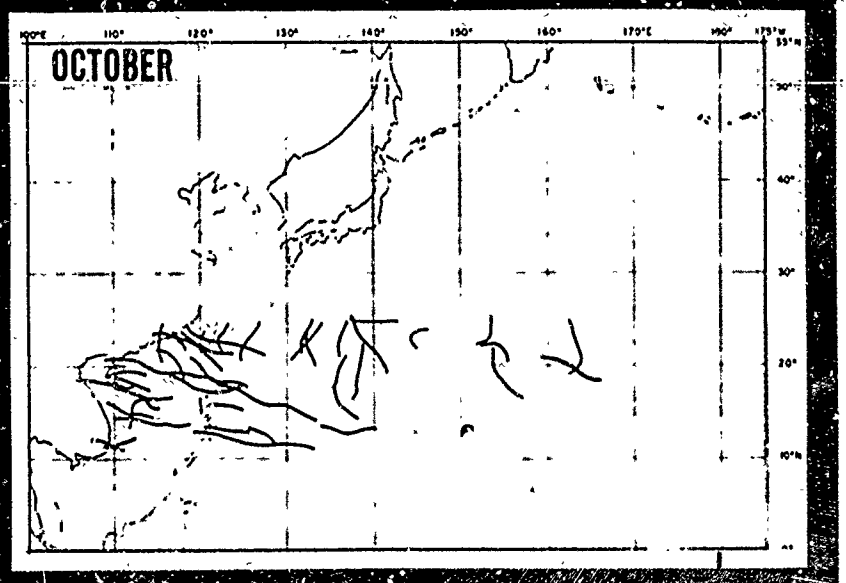
(b)

Figure 10. Track segments for tropical cyclones (1945-1969) experiencing a 20-knot or more intensity decrease in 24 hours occurring south of 25N for the months July - November.

(c)



(d)



(e)

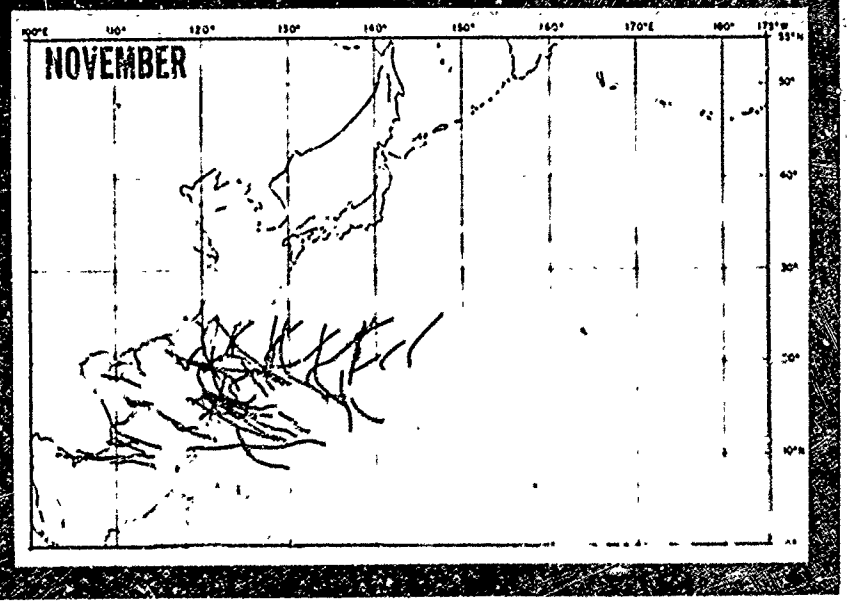


Figure 10.

(Continued)

It can be seen that most of the tropical cyclone "weakening" segments are associated with those storms reaching the Asian mainland or crossing the Philippines[2] or Taiwan, but certain exceptions do exist. In July, a number of northwesterly moving storms weakened over the open ocean in the area bounded by 15N - 25N and 125E - 130E. In August, a month that has a great deal of storm activity, surprisingly few storms weakened over the open ocean; while from September on, weakening storms were more apparent not only in the western North Pacific but also in the South China Sea.

Notice the general heading of the storms weakening over the open ocean throughout the 5-month period. In October and November, these low-latitude track segments are associated with recurving storms as the mean latitude of tropical cyclone recurvature moves south. This association may be explained by the fact that tropical cyclones tend to reach their maximum intensity just prior to or at recurvature and to decrease in intensity thereafter (Riehl, 1971).

---

[2]A detailed study of the effects of the Philippines can be found in "Changes in the Characteristics of Typhoons Crossing the Philippines," ENVPREDRSCHFAC Tech. Paper No. 6-72 (Brand and Blelloch, 1972).

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Hodge, W. T. and G. F. McKay, 1970: A computer program to select typhoon analogs and print out their descriptions, including subsequent changes. NWRC, First Progress Report, NAVWEARSCHFAC Project Order PO-90003.

Riehl, H., 1971: Intensity of recurving typhoons. NAVWEARSCHFAC Tech. Paper No. 3-71.

APPENDIX A

GEOGRAPHIC DISTRIBUTION OF 24-HOUR INTENSITY CHANGES (JULY - NOVEMBER)

The geographic variation of 24-hour intensity changes for tropical storms and typhoons (1945-1969) are presented in Figures A-1 through A-5, for the months July through November, respectively. Values are deduced from Brand and Gaya (1971). The values given in the following figures are from the general category that was independent of initial intensity and represent average intensity changes occurring from the present position to the following 24-hour position.

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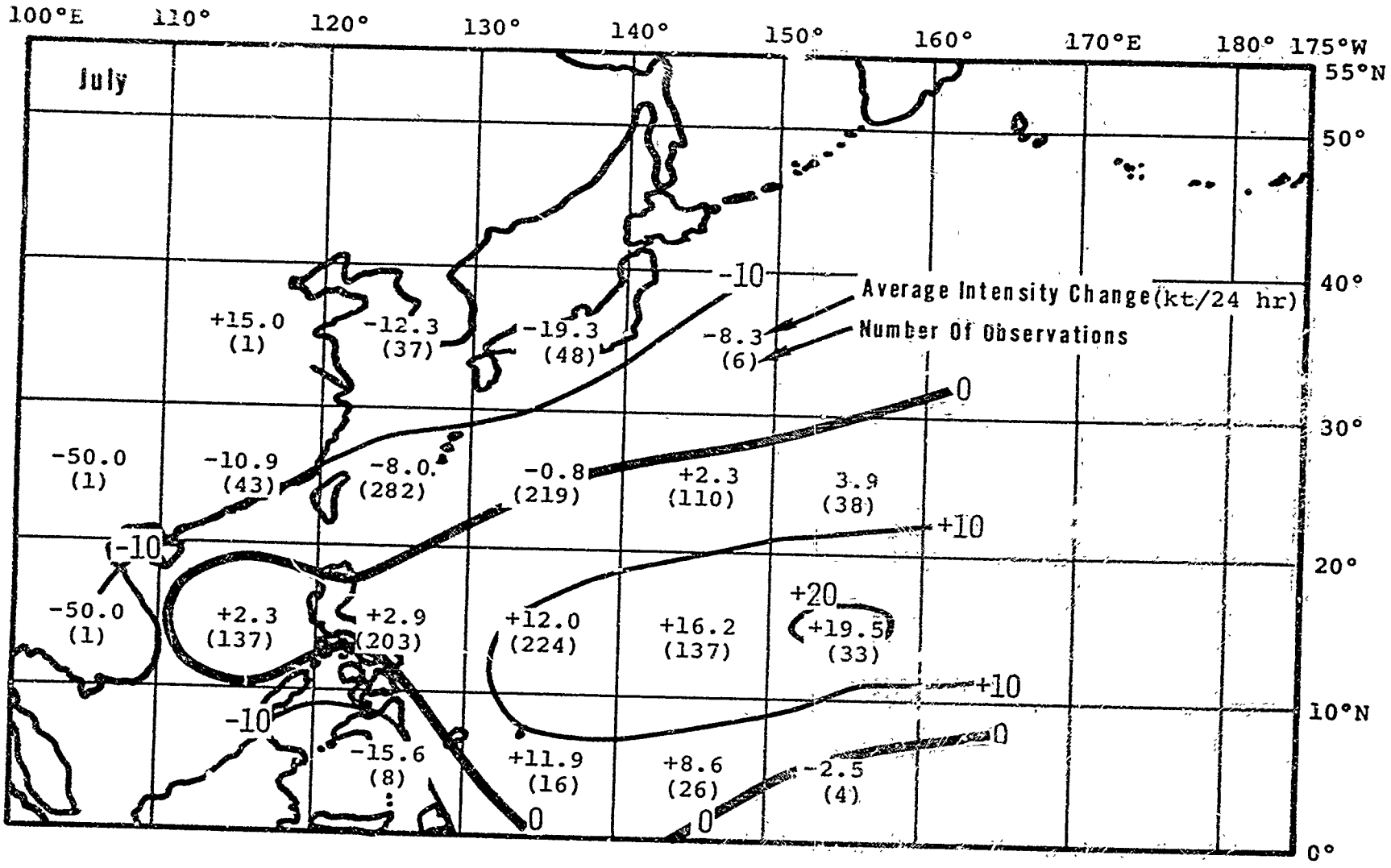

Figure A-1. July 24-hour intensity changes for tropical storms and typhoons (1945-1969).

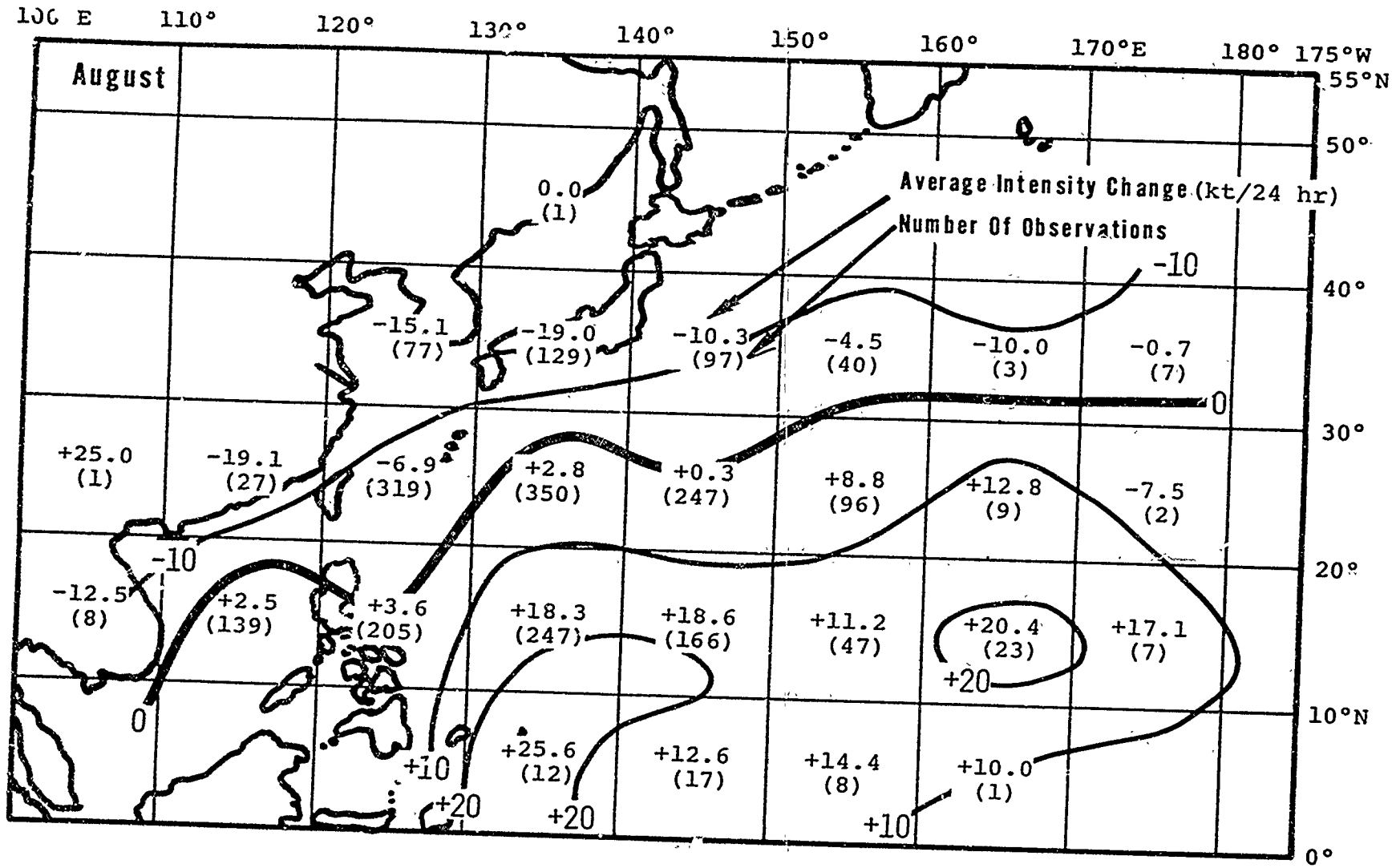

Figure A-2. August 24-hour intensity changes for tropical storms and typhoons (1945-1969).

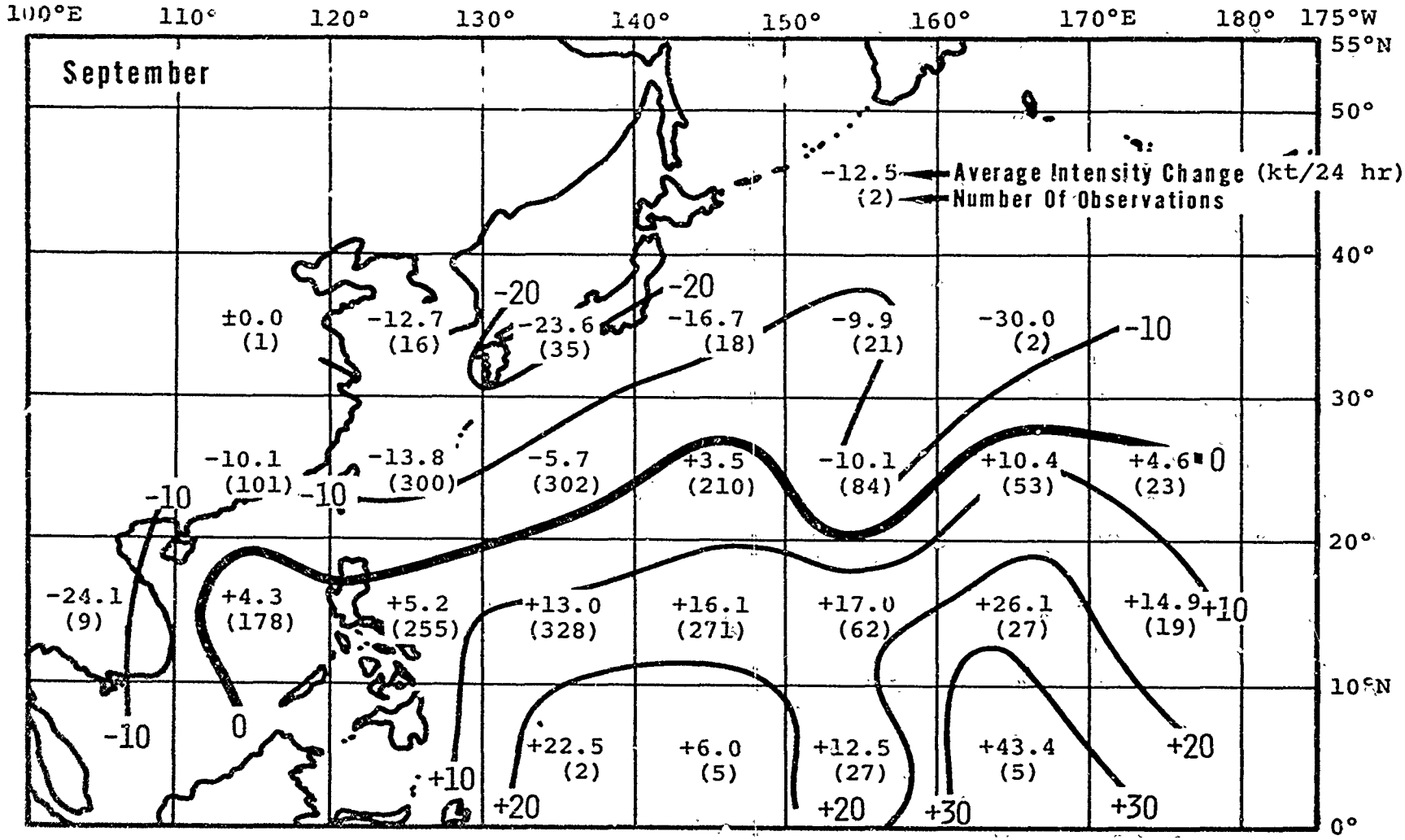

Figure A-3. September 24-hour intensity changes for tropical storms and typhoons (1945-1969).

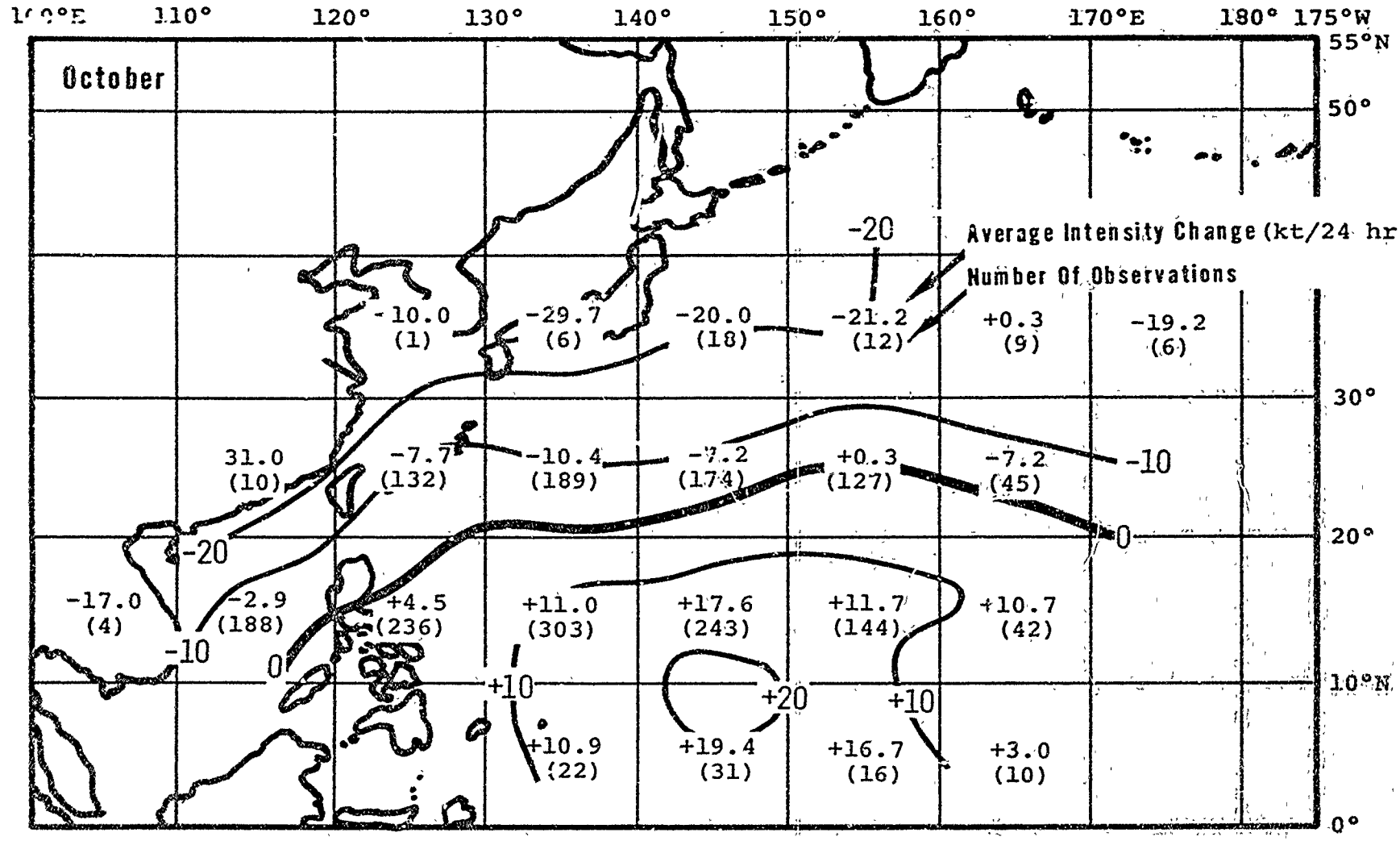

Figure A-4. October 24-hour intensity changes for tropical storms and typhoons (1945-1969).

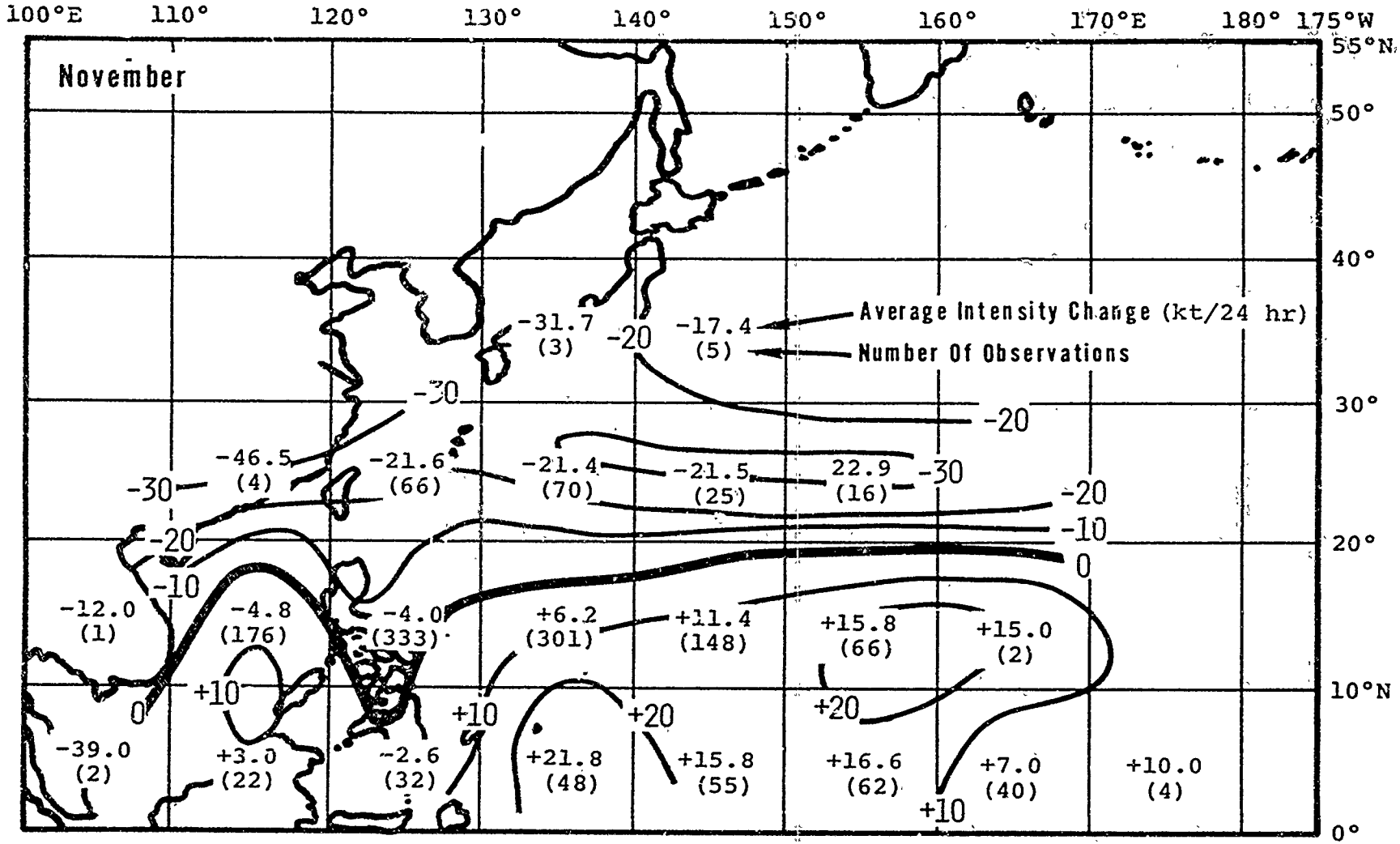

Figure A-5. November 24-hour intensity changes for tropical storms and typhoons (1945-1969).